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Abstract. Previous shock initiation run-to-detonation experiments on energetic materials were plotted with distance and time to get a single distance/time to detonation. Modern shots utilize enough gauges so that the distance-time data can be differentiated, which shows not only the usual inflection pressure point before detonation, referred to here as P_b, but also a second, low-pressure inflection, referred to here as P_a, that marks rapid ramp-up of the initiation. An analysis of the TATB based LX-17 and PBX 9502 in addition to the LLM-105 based RX-55 data shows that both P_a and P_b increase linearly with the initiation pressure created by the flyer plate. This contradicts the current method in the Tarantula failure/dead zone model, which uses constant pressure boundaries between reaction regions. Modeling changes required by the new data will be considered.

Keywords: Explosive, initiation, model, run-to-detonation
PACS: 82.33.Vx, 82.40.Fp

INTRODUCTION

The use of in-situ gauges in measuring shock initiation of energetic materials has allowed improved data to be collected in recent years [1-4]. This has allowed an expanded ability to develop models to fully understand the phenomena present. The challenge, naturally, is to develop a model that offers a simplified scheme with a minimum number of parameters and describes a multitude of different energetic materials that may react with different chemical kinetics. This paper describes a slightly new approach to this problem with preliminary work to date and a discussion of improvements needed.

METHOD

Older shock initiation experiments gave a run-to-detonation distance that marked the change from initiation to detonation. The run-distance-to-detonation point was found by plotting distance versus time for the data and finding where the slope changed from initiation to detonation. This led to the setting of a transition point in the Ignition and Growth model between initiation and detonation [5]. In order to model dead zones and failure, the Tarantula model added a "failure" region, which comes between initiation and detonation [6,7]. In this scheme, the failure-to-detonation transition is P_b, the pressure associated with old run-to-detonation data. A new, lower pressure is set at P_a, where initiation suddenly ramps up.

From this perspective, we have reconsidered modern shock initiation gauge data to see if the P_a parameter can be identified. Such an experiment performed by Gustavsen at LANL is shown in Figure 1 [1] and offers a number of in-situ gauges aligned on a wedge. The key is to have many gauges so that the data can be differentiated to get a wave velocity. Figure 2 shows this result as obtained from Figure 1, and we see that two inflection points appear to exist. The lower is P_a, seen experimentally for the first time.

Using this same approach, data for LX-17 (92.5 wt. % TATB/7.5 kel-F), PBX 9502 (95 TATB/5.0 Kel-F), RX-55-AA (95% LLM-105, 5% Viton by weight), and RX-55-AB (92.4 LLM-105/7.6 Kel-F) was utilized, which has also been taken at various temperatures [1-4]. The first step was to evaluate if any effect of the initial temperature could be observed and a plot of P_b as a function of temperature is shown in Figure 3. From this plot, it can be seen that there is no observable relationship even though our intuition would lead us to believe that a constant value at a given temperature might be evident.

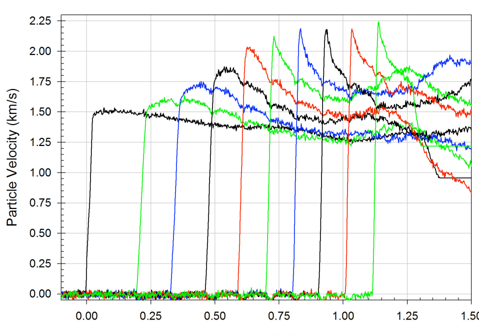

FIGURE 1. Los Alamos experiment 2S-64 on ambient LX-17 [1]. A Kel-F flyer was used at 3.13 mm/μs. Detonation occurs between the 5th and 6th gauges at 0.65-0.70 μs. The ramp-up to detonation starts at about 0.5 μs.

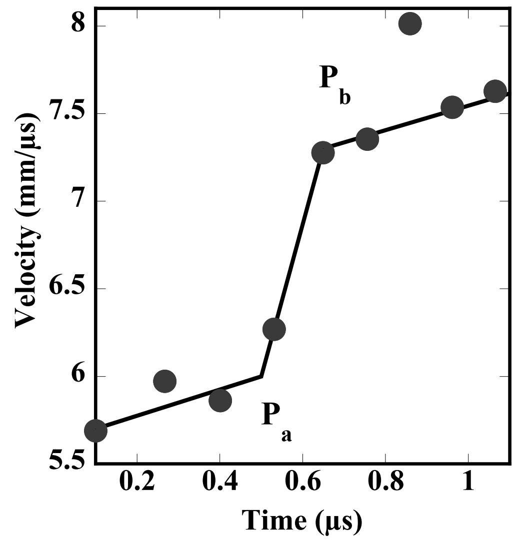

FIGURE 2. Differentiated data on LX-17 from Figure 1 showing the change in wave velocities. The parameters P_a and P_b are derived from the changes in slope of the velocity.

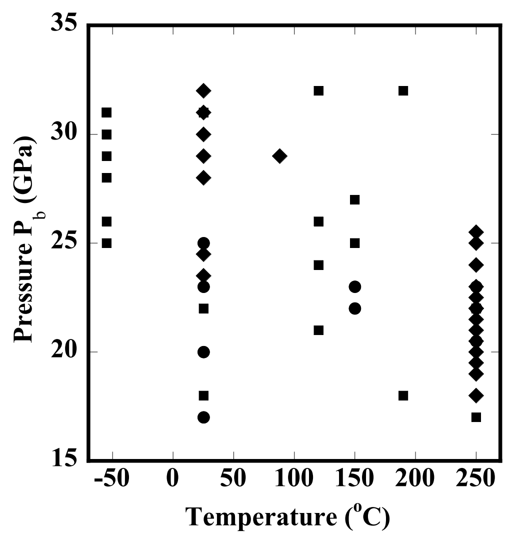

FIGURE 3. Plot of P_b as a function of the temperature of the shot for three explosives: LX-17 (diamonds), PBX 9502 (squares) and RX-55 (circles). There is no temperature dependence.

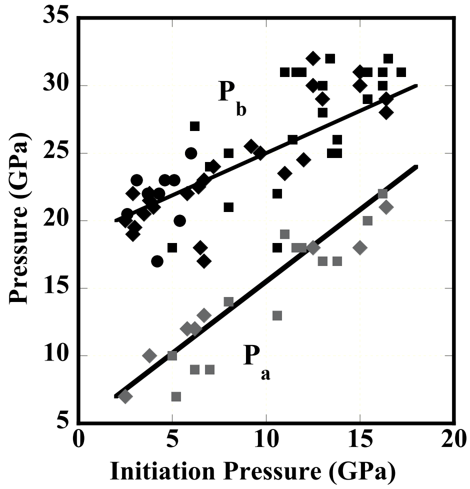

FIGURE 4. Plot of P_a and P_b versus the initiation pressure created by the flyer for LX-17 (diamonds), PBX 9502 (squares) and RX-55 (circles).

DISCUSSION

In Figure 4, the parameters P_a and P_b are plotted as a function of the initiation pressure as a result of the flyer impact. In these experiments, the flyer plates on the sabot are relatively thick so that the pressure is kept at the same value for the entire initiation process. All of the data, taken over a wide temperature range, falls into two lines, which rise with increasing pressure. This says that the onset of the ramp-up and the onset of full detonation both come at lower internal pressures for lower initiation pressures. This does not agree with the layout of both Ignition and Growth and Tarantula v1, which both use constant transition points for all problems. The new Tarantula v2, currently under construction, seeks to incorporate the results observed here.

It has been long observed that boosters have to be "overdriven" in the codes in order to get the correct answer to the problem. This may be caused by the pressure-dependent behavior seen here. Boosters are started at lower pressures and so should transition upward also at lower pressures.

SUMMARY

This preliminary work presents a technique that utilizes recent in-situ shock initiation data to utilize a feature in the Tarantula v1 (version 1) model that incorporates a "failure" region between initiation and detonation. These features are being incorporated into a later version (v2) of the code.

ACKNOWLEDGEMENTS

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